# Space Weather Technical Forecast

Issued on Wednesday, 01 March 2023 at 01:10 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Recent CME and HSS influences gradually easing on March 1st. Chance of M-flares, with slight chance of X-flares, primarily from AR3234.**

## Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Moderate, with an M8.6 flare observed at 28/1750 UTC, originating from AR3234 in the northwest quadrant. There are currently six sunspot regions on the visible disc, five are numbered, with a newly emerged unnumbered spot in the southeast quadrant. The largest region, AR3234, in the northwest quadrant is the most magnetically complex and contains a 'delta' spot. The region on the northeast limb could also reveal further complexity as it rotates further into view. The M8.6 flare in the northwest has produced a CME, which is undergoing modelling and analysis to determine any Earth-directed component. Currently, no Earth-directed CMEs have been observed on available imagery.

S**olar Wind / Geomagnetic Activity:** Solar winds have been strong during the past 24 hours, due to the waning effects of the recent two CME arrivals, with a peak of 781km/s at 28/0556 UTC. Solar winds are now steadily declining back towards elevated levels, currently ranging between 600-700km/s, which is probably due to a high speed stream (HSS) from CH79, which was initially masked by the recent CME effects. Density was below average. Total magnetic field strength has been moderate to weak, with a peak of around 10nT. The north-south component, Bz has varied weakly throughout, with a maximum southward orientation of -7nT. Phi angle has been predominately negative (towards the Sun). Geomagnetic activity started the period at G2/Moderate Storm level falling to G1/Minor Storm for one interval, but has been mostly Quiet to Unsettled since.

**Energetic Particles / Solar Radiation:** The high energy proton flux (greater than 10 MeV) as measured at GOES-16 has been steadily retreating to background levels through the last 24 hours. Electron flux started at mainly background, but has recently reached the high level threshold, with a peak of 1.32e3 pfu at 28/2220UTC. Electron fluence has started to increase, reaching 3.81e7 integrated pfu at 01/0000UTC.

## Four-Day Space Weather Forecast Summary

**Solar Activity:** Low to Moderate activity is forecast through the period, mainly due to the large, complex region AR3234 in the northwest quadrant. AR3239 in the far northeast may also start to contribute to the flare risk.

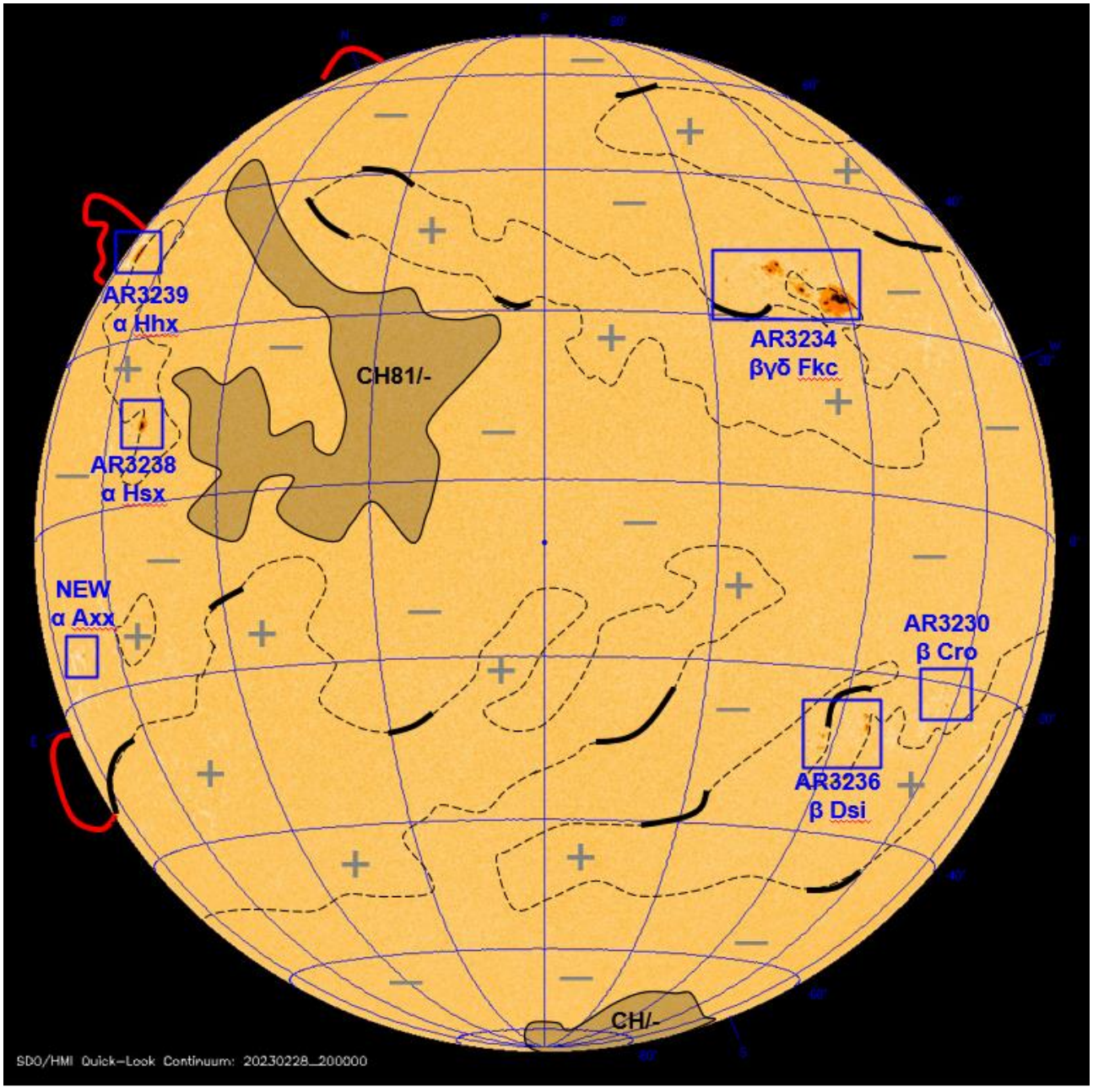
**Solar Wind / Geomagnetic Activity:** Recent CME activity is declining, with speeds decreasing towards the background high speed stream speed of 500-600km/s. No further CMEs are forecast to affect the Earth. Solar winds are expected to slowly decline towards 300-400km/s by the end of day 1 (01 Mar) as the high speed stream declines. Geomagnetic activity is forecast to start mainly Quiet to Unsettled, with a chance of Active intervals. Becoming mostly Quiet days 2 and 3 (02-03 March), although possibly becoming Quiet to Unsettled, with a slight chance of Active or G1/minor storm later on day 4 (04 March) due to possible HSS arriving from CH81/-.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

**Energetic Particles / Solar Radiation:** The high energy proton flux (greater than 2MeV) is below the S1/Minor storm level with only a slight chance of rising above due to any significant flares that occur, primarily from AR3234 in the northwest. High energy electron flux (greater than 2MeV) is expected to rise through the period, more persistently exceeding the high threshold on diurnal maximums. Electron fluence is expected to increase with a rising chance of exceeding the Active (1e8 integrated pfu) through the period.

**Figure 1. Solar Analysis Valid 28/2000 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

## Geomagnetic Storms:

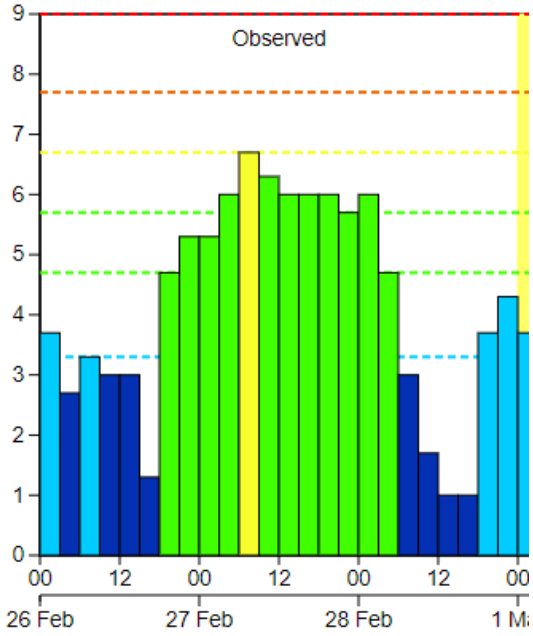
No CMEs are currently forecast to arrive at Earth during the forecast period.

The high speed stream from coronal hole 79 is currently connected to Earth, giving speeds ranging between 600-700km/s. This is expected to remain connected to Earth during the next 24 hours, with speeds gradually decreasing to background. A coronal hole in the north centre of the Sun may have been modelled by Enlil as affecting the Earth, but this appears unlikely to have significant effects, as the Earth is currently below the solar equator, with this hole well to the north. A large coronal hole (CH81-) in the eastern hemisphere is likely to bring a high speed stream (HSS), which is expected to arrive at Earth later on day 4 (04 March) or possibly just beyond this forecast period (05 March).

Geomagnetic activity is expected to be mainly Quiet to Unsettled on 01 March, with a chance of an Active interval, especially at first. Mostly Quiet for the remainder of the period, although activity may increase to Unsettled or Active intervals day 4 (04 March) due to the possible arrival of HSS from CH81/-, with a slight chance of a G1/minor storm.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | Yes | 10 | 1 | 1 | 20 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

**Figure 2: BGS observed geomagnetic activity over the past 24 hours.**




Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

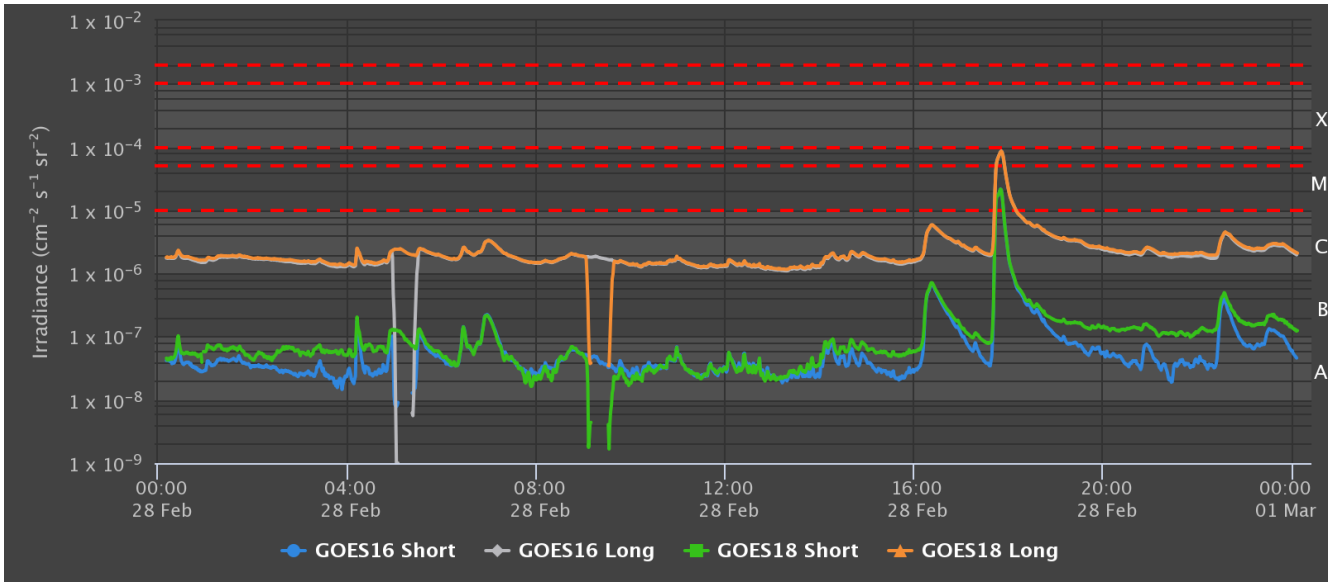
© Crown Copyright 2023. All Rights Reserved.

**Radio Blackouts - X-Ray Flares:**

There are currently six sunspot regions on the visible disc, with the risk of Moderate or Strong activity heavily biased towards AR3234 (Fkc/βγδ) in the northwest quadrant. This is a large region, with significant complexity, especially in the trailer region which contains a contorted delta spot. This region has recently produced an M8.6 flare (R1/R2 Radio Blackouts) and an associated CME, which has been emerging off the northwest. The CME will be analysed as soon as further coronagraph imagery is available to establish if it as any Earth-directed component. Ex-3229 has faded to plage close to the northwest limb. A newly numbered sunspot AR3239 on the northeast limb is continuing to reveal increasing complexity, and is associated with an area of bright flux, which could result in further significant flare activity.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | Yes | 65 | 60 | 50 | 50 |
| Very Active | R3 to R5 X Class | No | 20 | 20 | 15 | 10 |

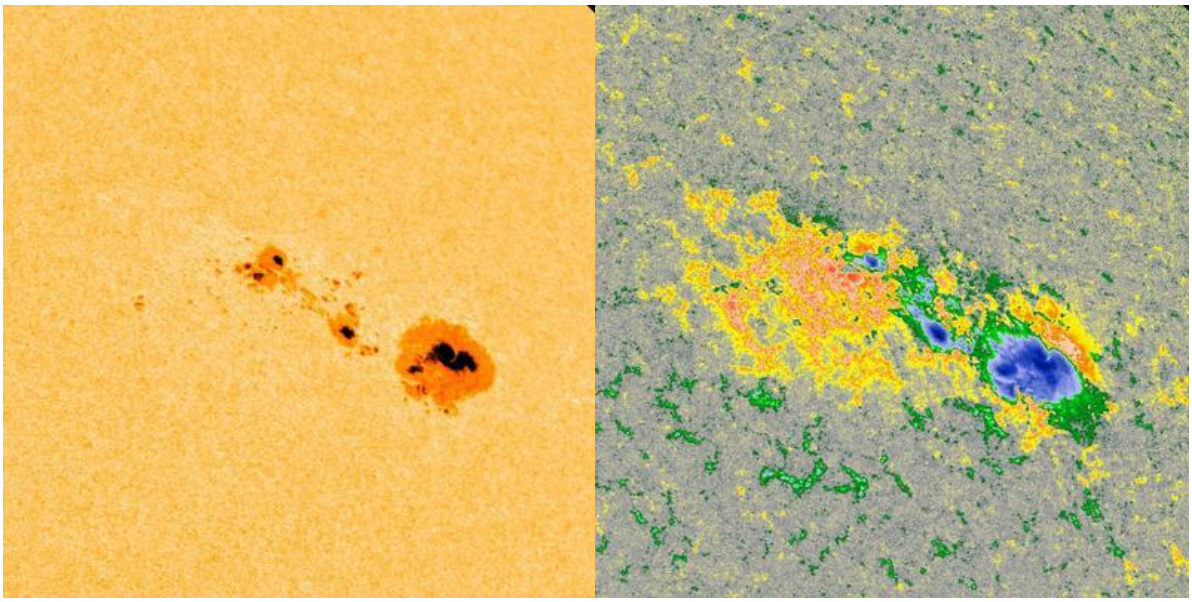
**Figure 3: GOES X-Ray Flares.**




Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

**Figure 4: AR3234 in HMI Intensitygram (left) and magnetogram (right) imagery, which shows the magnetic complexity of the region – with a 'delta' spot visible.**



## Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux, as observed by GOES16 has been declining, and is expected to gradually fall towards background. AR3234 in the northwest quadrant has the potential to produce further significant flaring. This, alongside any other lower risk flare activity from the other regions on the disc brings slight chance of flux rates climbing again and reaching the S1 Minor Radiation storm threshold, especially as the large complex region is in a prime location for Earth-directed solar storms.

| Radiation Storms<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 10 | 10 | 10 | 10 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

## High Energy Electrons Event (≥ 2MeV):

The recent CMEs and high speed stream are likely to have loaded the radiation belts with electrons. Initially these will have been displaced from the GEO orbit by the strong solar wind and increased geomagnetic activity. As the speed and activity eases, the electron flux is likely to increase sharply to above the high threshold. The high energy electron flux (greater than 2MeV) is expected to start at mainly moderate to high levels through the next four days, but reaching persistently high levels on diurnal maximum throughout the period.

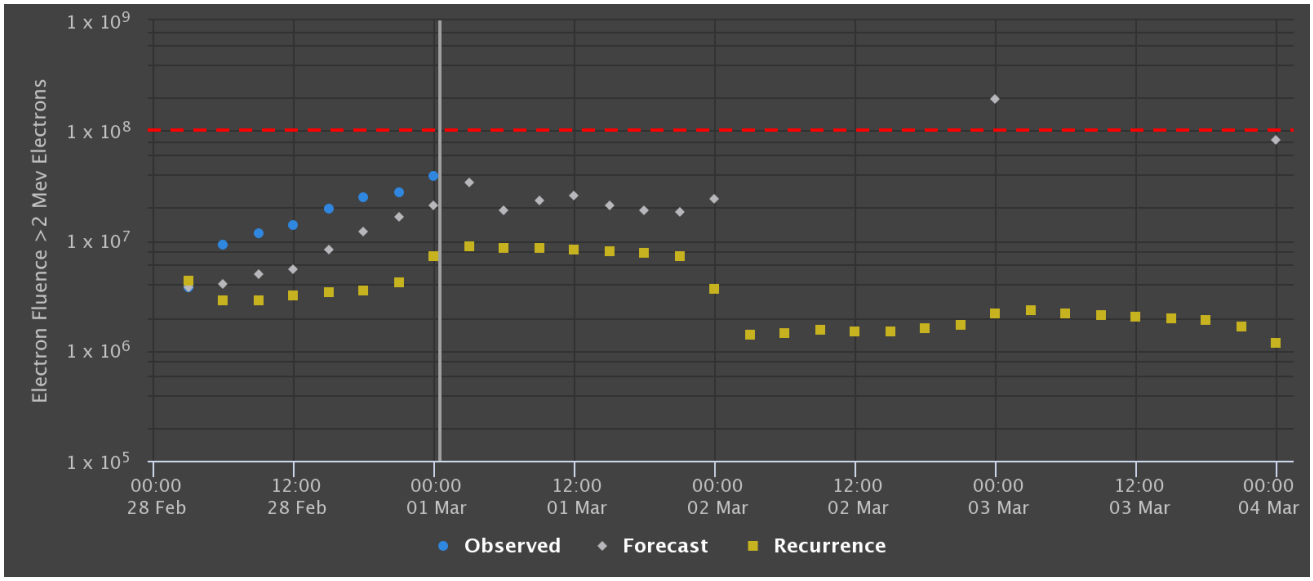
Electron fluence values are forecast to reflect this increase with a likelihood of exceeding the active (1e8 integrated pfu) later in the period.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 50 | 60 | 60 | 50 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 5 | 10 | 10 | 5 |

**Figure 5: MOSWOC REFM electron fluence and observations.**




Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.